Using FIA Data and GY Models for State-wide Forest Projections

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Overview:

- We consider a case in Maine where statute requires state-wide timber analyses periodically, and models are also requisite to assess impacts from implementing natural climate solutions—climate goals have been set to be carbon neutral by 2045. The Forest Vegetation Simulator (FVS) and other growth and yield (GY) models are being considered for statewide analyses for projecting timber supply and carbon outcomes. We assume and see some evidence that other States are facing similar questions.
- FVS is perhaps the widely used growth and yield model in the U.S., and we wonder if additional work could be done to ensure that it is verified and well calibrated for multiple user needs, across different domains, and at varied scales. Integrating Forest Inventory and Analysis (FIA) data with FVS could serve as the baseline data for many (larger) state and regional analyses and FIA data could be used to improve FVS estimation capabilities.
- As test case, we used FIA2FVS as the starting dataset and grew out Maine's forests. We found that this process was relatively easy, and we could generate "future FIA" estimates using this framework. More work will need to be done to ensure that the Northeast variant (FVS-NE) is well calibrated for Maine.

Summary:

In 2019, Maine's forest products industry had a total economic impact of $8.1 billion. The industry employed over 31,000 people, with $1.7 billion in labor income. Ensuring a sustained inventory is the first link in the supply chain that helps the forest sector thrive—namely, that mills stay open, and jobs remain intact. Recognizing that the forest has potential to produce more timber sustainably may allow the industry to grow. On the other hand, acknowledging the limitations of Maine's forests will hopefully reduce the risk of creating overcapacity in Maine's forest products sector. Monitoring and projecting harvest, mortality and the resultant distribution of timber size classes, forest types or species, and other forest conditions is important, as these metrics serve as proxies for overall forest health" (MFS 2022, pp. 2-3). The Maine Forest Service (MFS) periodically conducts Timber Supply Analyses as directed by statute: (i.e., "…project future timber supply using forest models based on growth, harvest, and other dynamic factors affecting the forest." (12 M.R.S. §8877-A (3))). On-going work at MFS uses Woodstock, an optimization modeling platform capable of improving decisions about resource management. One of the key inputs in Woodstock are GY curves which are commonly developed using FVS or some other GY model. To date, efforts have focused mostly on using FVS-ACD (Weiskittel et. al. 2017) and The Open Stands Model (Hennigar, 2019). Here we project Maine's forests using FIA2FVS tables as input into FVS-NE; compare modeled growth rates to FIA growth rates; and consider approaches for verifying and calibrating FVS for statewide and other modeling efforts.

Key Concepts for FVS Users:

- Utilizing FIA data could offer a solution for verifying and calibrating FVS.
- FIA2FVS (Shaw and Gagnon 2020) converts the FIA data for ready use in FVS. Users can easily download the FIA database, upload it into FVS, and grow-out stands.
- For users who want results to align with FIA population estimates, the FVS_STANDINIT_COND table allows growth at the plot/condition level. Users can extract FIA inventory year from the GROUPS column (otherwise FVS.INVYEAR == FIA.MEASYR); FVS outputs can then be linked back to FIA tables to match population estimation.
- For verifying FVS-NE we took an approach that grew the first complete annual inventory in Maine forward 15 years (i.e., 3 full cycles) and compared FVS and FIA gross volume growth rates taken as a weighted average at the plot / condition level. FVS growth rates appeared to exceed FIA growth rates.
- Using the publicly available legacy tree database (Radtke et al. (2023), in review) we estimated volume at the tree level (2015) and the resulting NSVB volume equations (https://charcoal2.cnre.vt.edu/nsvb_factsheets/; Westfall et al. The no triples keyword helped consolidate the tree table.). Statewide estimates using NSVB versus the current equation in FVS-NE yielded similar results (fig. 1).
- Preliminary results suggest that FIA mortality estimates exceed FVS-NE mortality estimates resulting in over-estimates of net growth across Maine.
- A solution that we have not fully vetted, but one that does increase mortality, involves modifying maximum density for the stand and the mortality distribution pattern using the BAmax keyword. However, adjusting SDImax directly may ultimately prove a better solution, if base mortality functions in FVS-NE are not refit.
- While FVS growth rates appear high, we observed that FVS maintained the relative growth-rates as they relate between forest types (table 1).

Management Applications/Future Directions:

- MFS will continue to explore different methods for projecting Maine's Forests.
- Questions remain about whether the Northeast Variant can be calibrated for Maine's forests, or whether certain models would need re-fit.
- Development of the Acadian Variant of FVS (Weiskittel et al. 2017) continues where models have been re-fit using contemporary data sources. Implementation in the current FVS framework seems likely, yet some obstacles remain.
- Presently the Open Stands Model remains a viable option for projecting Maine's forest.
- The user community might consider whether sub-regional variants using other programming languages (e.g., C# & R) could be a viable option. These sub-variants would need to be generally stable with some reporting of error.

- There seems to be some interest in using FIA data to verify and calibrate FVS variants. With regards to verification, could USDA Forest Service staff (hopefully with assistance from the user-community) provide error statistics at sub-region scale with each update? One starting point might be growing the first cycle of FIA data forward to the most current cycle to compare FVS results on non-harvested lands by State, forest type, physiographic code, and other domains of interest (remeasurement period: FIA.PLOT.REMPER would need to be considered here). Regarding calibration, could keyword files be kept in a repository after users have calibrated a variant or domain within a variant?
- Incorporating NSVB along with estimation procedures for other pools (concurrent with FIA) into the current FVS framework would be very welcome.
- To the extent that other States seek to project timber supply, carbon, and other forest characteristics, the authors wonder if there is potential for between-state collaborations and collaboration with FVS staff, Forest Service Sustainability and Planning staff, particularly as it pertains to Forest Action Plans and FIA analysts as it pertains to 5-year state reports. FIA data could be projected forward to generate future FIA population estimates (fig. 2).
- In addition to considering FVS for large area timber supply and carbon projections. states are considering how other models such as Woodstock, Landis (Simons et al. 2021), RPA (https://www.fs.usda.gov/research/inventory/rpaa/2020), and The Carbon Budget Model (CBM: https://natural-resources.canada.ca/climate-change/climate-change-impacts-forests/carbon-accounting/carbon-budget-model/13107) could be used or integrated into their modeling frameworks to meet their needs.

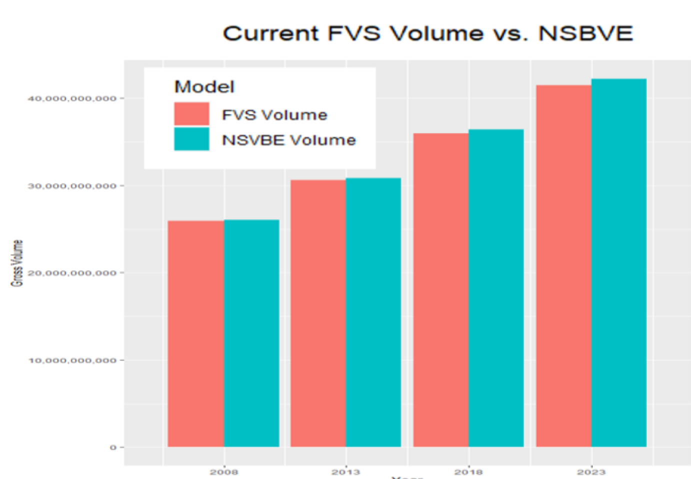
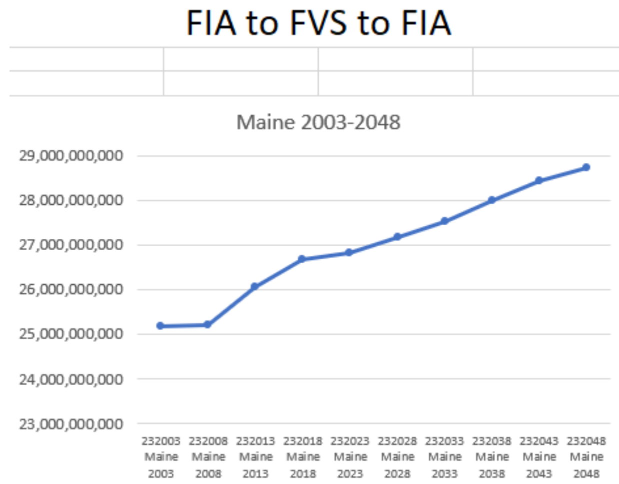


Figure 1—Comparison between FVS and NSBVE.

FIA Forest Type Group	Growth (cords/acre/year)	
	FIA sound	FVS gross
Exotic softwoods group	1.10	1.88
White / red / jack pine group	0.76	1.04
Oak / pine group	0.71	1.08
Oak / hickory group	0.61	0.88
Loblolly / shortleaf pine group	0.60	0.77
Spruce / fir group	0.51	0.73
Aspen / birch group	0.51	0.74
Maple / beech / birch group	0.49	0.70
Elm / ash / cottonwood group	0.18	0.65
Other hardwoods group	0.10	0.29

Table 1—Comparison between FIA and FVS growth volumes rates by species group.

FIADB-API v2.0.5 – View Report
Estimated parameters
Numerator attribute number and description: 0014 Net merchantable bole volume of live trees (at least 5-inches d.b.h./d.r.c.), in cubic feet, on forest land
FIADEF as the forest land definition
State/EVAL_GRP(S):
Maine 232003
Maine 232008
Maine 232013
Maine 232018
Row variable: EVALID (based on values from the Current inventory)
Column variable: Tree class (based on values from the Current)
Filtering clause(s) applied to numerator and denominator:
None



EVALID	Total	Growing Stock	Rough Cull	Total volume w/o rotten cull
Total	**104,660,362,662**	**96,963,465,536**	**6,212,295,259**	**103,175,760,795**
232003 Maine 2003	25,580,251,706	23,930,483,273	1,263,893,573	25,194,376,846
232008 Maine 2008	25,474,349,023,	23,789,919,608	1,432,683,641	25,222,603,249
232013 Maine 2013	26,356,383,134	24,530,104,531	1,534,461,568	26,064,566,099
232018 Maine 2018	27,249,378,799	24,712,958,124	1,981,256,476	26,694,214,600
232023 Maine 2023				*26,824,493,465*
232028 Maine 2028				*27,177,040,734*
232033 Maine 2033				*27,545,165,142*
232038 Maine 2038				*27,999,675,259*
232043 Maine 2043				*28,435,769,253*
232048 Maine 2048				*28,731,069,678*

Figure 2—Conceptual figure showing FIA to FVS to FIA with future FIA estimates.

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